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Towards achieving environmental sustainability target in Italy. The role of energy, real income and globalization☆

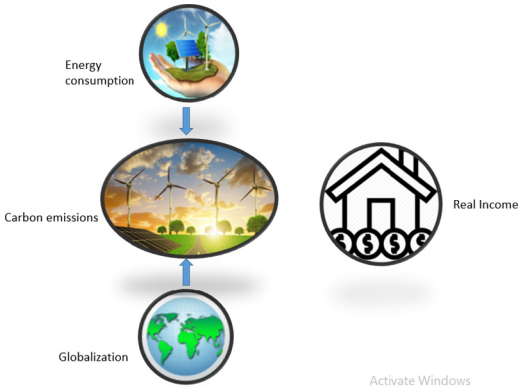
Seyi Saint Akadiri *, Mariam M. Alkawfi, Sevin Uğural, Ada Chiozie Akadiri

Faculty of Business and Economics, Department of Economics, Eastern Mediterranean University, Famagusta, North Cyprus, via Mersin 10, Turkey

HIGHLIGHTS

- Energy and globalization are crucial in achieving environmental quality.
- Real income has no significant impact on environmental pollution.
- We found environmental quality driven by energy and globalization.
- Inelastic impact in the short-run and elastic impact in the long-run.
- Environmental policies with growth objectives sustain the environment.

GRAPHICAL ABSTRACT



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ABSTRACT

One of the major challenges several economies of the world is facing today is striking a balance between mitigating environmental degradation amidst the dire desire for economic growth and environmental sustainability. In order to reduce environmental pollution and sustain the environment, countries around the world are embarking on several policy measures to ameliorate climate change and reduce greenhouse gas emissions. On this premise, this study investigates the role of energy, real income and globalization in the quest to achieve environmental sustainability in the case of Italy using Autoregressive Distributed Lag model for empirical estimators and Toda and Yamamoto predictive methodology over the period 1970–2014. Based on empirical results, we found that a percent increase in kg oil equivalent per capita of energy consumed and globalization index led to 0.928% increase and 0.914% decrease in metric ton per capita of CO_2 emissions in the short-run, and 1.796% increase and 1.769% decrease in metric ton per capita of CO_2 emissions in the long-run, while the real income has no significant impact on the metric ton per capita of carbon emissions level both in the short- and long-run. The autonomous term also showed an interesting result, we found that, holding other factor constant, a percent increase in the constant term will lead to 1.879% decrease in metric ton per capita of carbon emissions in the short-run, and 3.635% decrease in metric ton per capita of carbon emissions in the long-run thus, we infer that Italy has been successful in balancing environmental conversation policies with macroeconomic objectives. This study provides credible policy suggestions for policymakers in energy intense economies around the world.

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* Corresponding author.
E-mail addresses: seyi.saint@emu.edu.tr (S.S. Akadiri), sevin.ugural@emu.edu.tr (S. Uğural), ada.akadiri@emu.edu.tr (A.C. Akadiri).

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1. Introduction

Globally, environmental issues are continuously gaining much consideration and which has made Italy no exception; the nation joined the European convention; the EU Emissions Trading System EU-ETS and the related protocols since 1979 (Institute for Environmental Protection and Research, 2014). A large part of global climate change and the greenhouse effect is due to carbon dioxide (CO_2) emissions and other greenhouse gases (Lee and Chang, 2009). The CO_2 emissions are considered as the source of 90% of all emitted greenhouse gases (GHGs) in the transportation field (Nocera and Cavallaro, 2011). Therefore, CO_2 emissions have received considerable attention regarding reduction of polluting gases. This paper investigates the role of globalization, kg equivalent per capita of energy consumed and real income/output (economic growth) in the quest of achieving sustainable cleaner environmental in Italy. We proxied metric ton per capita of CO_2 emissions for environmental pollution in order to evaluate the Italian consumption trend in terms of efficient energy sources, as indication for Italy commitment towards reducing CO_2 emissions.

Recently, the relationship between CO_2 emissions, globalization, energy consumption and economic growth has been at the center of attention among policymakers and academic scholars (see Shahbaz et al., 2017; Shahbaz et al., 2018a, 2018b; Akadiri and Akadiri, 2019a, 2019b). One common conclusion observed in these studies regarding the interaction among these variables on CO_2 emissions is that, globalization, economic growth and energy consumption significantly increase carbon emissions. Globalization as it is encourages technical innovation, boosts environmental standards, improves the environmental condition if well managed, enhances total factor productivity by increasing trade activity and rising economic activity via foreign direct investment and transactions of advanced technology (Shahbaz et al., 2013). Globalization also enables governments to enforce international trade policies by reducing trade barriers to the import of energy-efficient technologies (Shahbaz et al., 2017). On the other hand, globalization is harmful to the environment. It accelerates the transfer of pollution to nations via trade of non-renewable energy sources where there are inadequate environmental regulations. Thus, globalization is also negatively related with growth and positively associated with CO_2 emissions (Snyder, 2008).

Several empirical studies have examined the relationship between globalization and energy consumption and its impact on the environment (Lucas et al., 1992; Baek et al., 2009; Chen and Chen, 2011; Chang et al., 2013; Leitão, 2013; Shahbaz et al., 2013; Leitão, 2014). Shahbaz et al. (2015a, 2015b) studied the impact of globalization and energy consumption on CO_2 emissions in China and concluded that globalization has a decreasing effect on CO_2 emissions, while any attempt to reduce energy consumption through energy conservation policy will slow-down or hurt economic growth process in China. Leitão (2014) also argued that globalization stimulate the environmental pollution. Energy consumption is an important factor in economic growth process, however it also has a negative impact on the environment. The higher the kg oil equivalent per capita energy consumed, the higher the economic growth, and hence increases in CO_2 emissions. On the other hand, economic growth stimulates increase in kg equivalent per capita of energy consumed. The more the increase in kg oil equivalent per capita of energy consumed, the higher the CO_2 emissions level (Saidi and Hammami, 2015; Sarkodie and Adams, 2018; Sarkodie and Strezov, 2018a, 2018b).

Integrating a nation into a global economy is an impetus for economic growth (Marber, 2005). Globalization improves the environmental quality, thus, when a country reaches higher living standards through globalization, people awareness increases and consequently they demand for improved environmental quality. In any globalized economies, trade liberalization is eminent (Copeland and Taylor, 1994; Copeland, 2005). Thus, it becomes expedient for such nations to prioritised clean and safe environment both for the immediate and future generation. This is done by enforcing energy conservation policies and sound environmental regulations which will lead to the adoption of energy-efficient technologies. As countries become energy-efficient and technologically designated within environmental standards, this motivates them to reduce CO_2 emissions using associated environmental legislation (Goher-Ur-Rehman and Servaas, 2016). Thus, globalization is a major determinant in economic growth and environmental sustainability process (Leitão, 2014).

Italian globalization process, no exception, also raises the environmental concerns. Since globalization via trade stimulate increase in energy consumption which in turn promote economic growth, while increase in economic activities are expected to increase environmental pollution and/or lead to reduction in environmental degradation if properly managed, then increase in kg equivalent per capita of energy consumed and real income/output necessitates usage of efficient technology via meeting cleaner and sustainable environmental standard. This motivates us to investigate the role, interaction and linkage between globalization, energy consumption and real income/output on environmental sustainability pursuit of Italy overtime.

The contribution of this study is of three-folds: First, using the graphical illustrations, we found that Italy has been successful in fighting environmental pollution due to decrease in the metric ton of carbon emissions overtime, which signifies a move towards cleaner and sustainable environment for the nation. This result is substantiated via empirical analysis. We find that increase in globalization index, kg oil equivalent per capita of energy consumed and real income/output[1] have decreasing impact on CO_2 emissions level in Italy both in the short- and long-run. Second, globalization index and kg oil equivalent per capita of energy consumed had inelastic impact on the CO_2 emissions level in the short-run and elastic impact in the long-run, while the autonomous term show higher elastic impact in both the short- and the long-run. This indicates that variations in these macroeconomic variables would have a stable and cleaner long-run environmental sustainability impact on both the present and future generation in the case of Italy. Finally, we find that, Italy is an energy-independent economy, i.e., the nation does not depend on energy consumption/production and real income to grow. Thus, energy and environmental conservation and protection policies would not hurt or slow down economic performance of Italy as the nation energy/environmental conservation policies are in tune with the macroeconomic objectives. From policy suggestions, we propose that governments and policymakers that prioritised greenhouse gas emissions reduction should balance their energy and environmental conservation and protection policies with their macroeconomics objective, if any meaningful environmental sustainability is to be achieved for the immediate and future generation.

The remaining sections of this paper are organized as follows: Section 2 presents environmental policy in Italy. In Section 3 we discuss data and the adopted methodology for the study. Section 4 is divided into two empirical results and empirical discussion. Section 5 provides the conclusion remarks with suggestions.

2. Insight into environmental sustainability measures in Italy

Reviewing the developments in the environmental policy in Italy during the period of the study, it can be said that Italy has made some progress towards reducing environmental pollutions. The decarbonation policy in Italy, generally involves two main paths; the increase in gas usage until reached the highest share in 2010, and using renewable plants for power generation, however gas still dominates the fuel mix though (Virdis et al., 2015; Emir and Bekun, 2018; Akadiri and Akadiri, 2019a, 2019b) (Fig. 1).

Following the trend in industrial economies, CO_2 emissions in Italy had risen in the late of 1940's reaching 76% until 1974 when it sharply falls to 46%, mainly due to replacing oil with natural gas (Boden et al.,

[1] In this study, we use economic growth and real income/output synonymously.

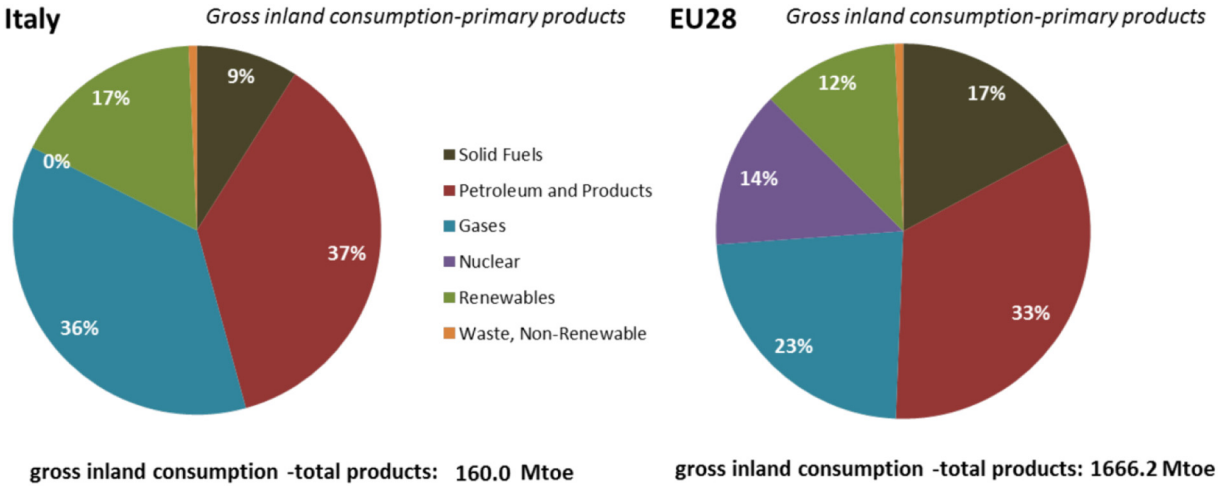

Fig. 1. Gross inland consumption-primary products of Italy and the EU 28-member states.

2011). For example, in transportation sector, a tremendous effort has been made towards ensuring efficient use of energy in such a way that, about 77% of vehicles in Italy are now natural gas-powered, a policy which is line with the European Union climate and energy targets 2020 (IEA., 2016). As presented in Fig. 2 CO_2 emissions initially increased during 1970 to 1974 then started to decrease. This reduction is due to the change in the energy policy in Italy towards more consumption of natural gas instead of oil as a result of oil price shock. According to the International Energy Agency (2016) report, between the period 1950–1974, metric ton per capita of CO_2 emissions grew rapidly by a factor of 7.5 and persistently fluctuate and progressively decreased from 2008.

The reduction in the metric ton per capita CO_2 emissions in Italy can be attributed to two reasons; one, because of the increase in the share of natural gas in the fossil-fuel basket, and the financial global crisis as graphically illustrated in Fig. 2 and empirically observed in the structural break dates obtained in Section 4. Italy joined the Kyoto Protocol with the other 28-EU countries, and was able to reduce the gap between GHG emissions and Kyoto target from 37.09 in 2008 to −0.87 in 2012.[2] The significant reduction in Italy's GHG emissions was a result of the economic crisis and falls in industrial output in that period (IEA, 2016). Regarding the Europe 2020 Strategy, Italy launched National Reform Programme (NRP) in 2013 to achieve three set out targets; the reduction of GHG emissions; the increase of renewable energy generation; and the increase in energy efficiency (Özokcu and Özdemir, 2017; Richmond and Kaufmann, 2006). According to the Council of European Union report (2015), Italy has established "National Energy Strategy" targets which focuses on year 2020 short-run targets with potential long-run 2030 and 2050 targets, respectively. These strategies are developed to reduce consumption of primary energy such as fossil-fuels by 26% by 2050.

Italy being a member in the European Civil Aviation (ECA), has common environmental concerns with other member countries, with the purposes to reduce carbon emissions generating from the aviation sector. ECA in their report, recorded that Italy has made significant efforts towards emissions reduction, especially in air transportations and environmental related program such as Clean Sky Program, and that by 2050, the nation is expected to achieve 40% of their environmental policies targets via energy-saving and energy-efficient technology (ENAC, 2012). Establishment of the Italian National Energy Strategy (INES) prioritised environmental pollution reduction and promotion of cleaner and sustainable environment as a clear goal to be achieved. For example, the long-run shift in the power sector by reducing the share of oil in the electricity generation-mix from 51% in 1995 to 5% in 2015 (IEA, 2016).

According to the country report conducted at Ecologic Institute (2014), Italy has strategic policy with an emphasis on "green growth" elements regarding economic improvement in the energy sector and the 2020 target non-ETS emissions reduction target. It is interesting to mention that Italy uses different energy-mix from the one used by the rest of 28-EU countries; the natural gas, which plays an important role with share of 36% of total Italian mix in 2013 (European Commission, 2015).

Nocera and Cavallaro (2011) in their analysis call for more comprehensive strategy in order to reduce CO_2 emissions generated by the transportation sector in Italy. While others believe that the global warming is unavoidable, even if Italy was able to reduce carbon emissions. Moreover, they claim these emissions may have positive impact and could benefit the agriculture sector by the carbon fertilization effect (CFE)[3] (Carraro and Sgobbi, 2008; List and Strazicich, 2003).

However, it is claimed that environment issues in Italy have less priority to the government compared with other European Union countries. One of the most criticisms facing Italian environmental policy is the missing comprehensible plan to reduce carbon emissions (Virdis et al., 2015). Another critique of the environmental policy in Italy posit that the nation lacks explicit carbon and the environmental tax, and that there is no specific target in terms of CO_2 emissions (Edoardo, 2014).

Carbon dioxide emissions is the largest product of the GHG emissions and it remains one of the main sources of environmental degradation (Stern, 2004), thus, it is essential to frequently examine the impact of carbon emissions on the immediate environment, the ruin it can cause for the future generation, and its interaction and interconnectedness with other macroeconomic variables, such as globalization, energy consumption and economic growth as examined in this present study. Thus, it has become expedient to explore the environmental policy the nation has put in place overtime via evaluating the role specific macroeconomic indicators have played towards achieving environmental sustainability in Italy.

3. Data and methodology

This study examines the role of globalization, energy consumption and real income in the attainment of environmental sustainability targets of Italy. To achieve our research objectives, we employ the

[2] Million tonnes of carbon dioxide-equivalent ($MtCO_2$-eq).

[3] A larger amount of carbon dioxide in the atmosphere would increase the plants growth, which use carbon dioxide during photosynthesis, and increase crop yields.

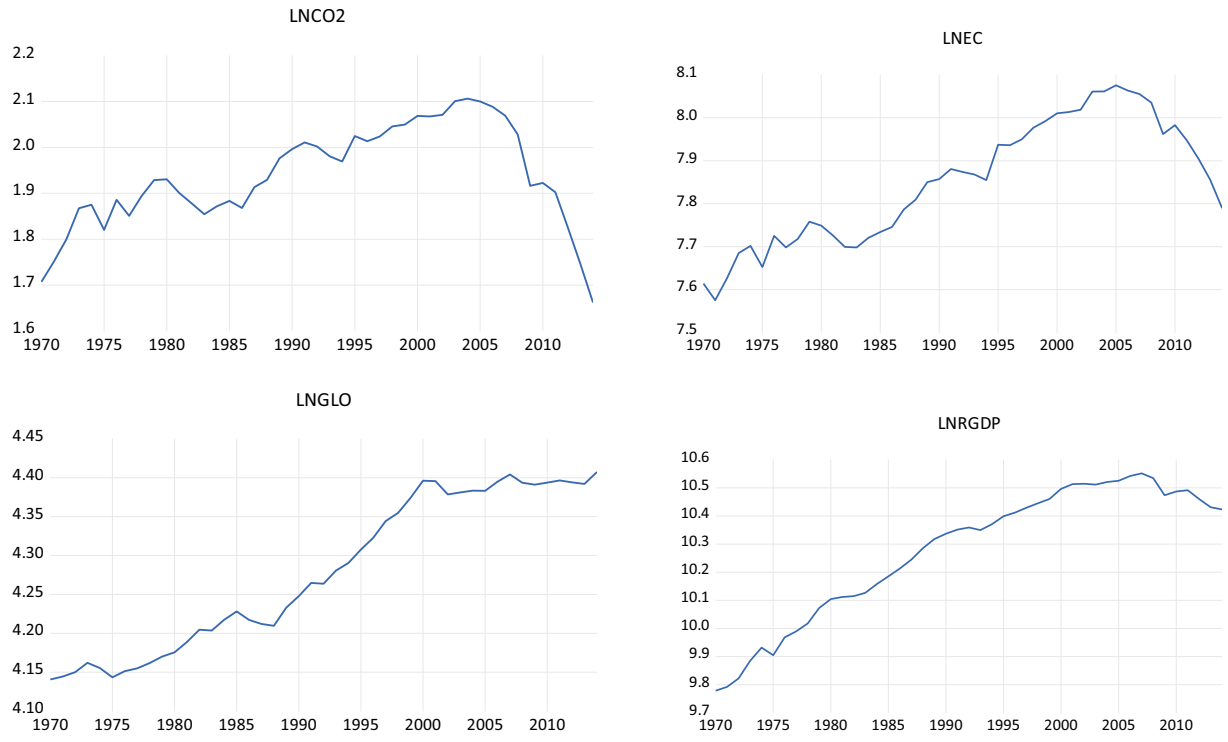

Fig. 2. Graphical plots of the natural logarithms of $lnCO_2$, lnEC, lnRGDP and lnGLO.

autoregressive distributed lag model for empirical estimators and Toda and Yamamoto (1995) causality method for predictive analysis using annual frequency data over the periods 1970–2014. In Table 1, we report the indicators, variables abbreviation, data unit of measurement and data source respectively.

We specified the model apirior expectation between the variables of interest as follow:

$$CO2_t = f\left(\mathrm{EC}_t^{\beta_1}, RGDP_t^{\beta_2}, \mathrm{GLOB}_t^{\beta_3}\right)\ldots \quad (1)$$

We rewrite Eq. (1) in natural logarithm as shown below:

$$\ln \mathrm{CO}_{2t} = \beta_0 + \beta_1 \ln \mathrm{EC}_t + \beta_2 \ln RGDP_t + \beta_3 \ln GLO_t + \varepsilon_t \ldots \quad (2)$$

where, β_i (1, 2, 3) is the slope parameters, ε_t is the error terms. If all things being equal (ceteris paribus) it is expected that, decrease/increase in $\ln EC_t$, $\ln GLO_t$ and $\ln RGDP_t$ would lead to decrease/increase in CO_2 emissions level (environmental pollution).

The unrestricted error correction form of the ARDL model for this study is specified below in Eq. (3):

$$\Delta \ln CO_{2t} = \gamma_o + \gamma_{co_2} \ln CO_{2t-1} + \gamma_{ec} \ln EC_{t-1} + \gamma_{rgdp} \ln RGDP_{t-1} + \gamma_{glo} \ln GLO_t + \sum_{i=0}^{p^1} \alpha_{\cos} \Delta \ln CO_{2t-1} + \sum_{i=0}^{q^2} \alpha_{ec} \Delta \ln \mathrm{EC}_{t-1} + \sum_{i=0}^{q^3} \alpha_{rgdp} \Delta \ln \mathrm{RGDP}_{t-1} + \sum_{i=0}^{q^4} \alpha_{glo} \Delta \ln \mathrm{GLO}_{t-1} + ECM_{t-1} + \mu_t \quad (3)$$

Table 2 report the summary statistics which includes; the mean, median, max, min, standard deviation, skewness, Kurtosis and Jarque-Bera (JB) test statistic which is specified under the null hypothesis of normal distribution. Based on the JB statistic results, we could not reject the null hypothesis; this indicate that the series are normally distributed.

We presents the Pearson correlation coefficient results in Table 3. Correlation coefficient estimates is a test that show how linearly two or more variables are correlated. Understanding of the relationship between variables will help empirical analysis to substantiate whether there is any relationship among variables or not and how strong or weak the relationship might be. In addition, the estimates are used to gather information about the potential signs that may be present between empirical variables.

From the results presented in Table 3, we found a strong estimated correlation coefficients among CO_2 emissions, real income, energy consumption and globalization respectively. Results show a significant, strong and positive estimated correlation coefficients between CO_2 emissions and energy consumed (0.809), between globalization and CO_2 emissions (0.510), globalization and energy consumption (0.903), real GDP per capita and CO_2 emissions (0.667), real GDP per capita and energy consumption (0.939) and between real GDP per capita and globalization (0.936) respectively. This signifies that the variables are highly linearly correlated and there is functional relationship among the series. Thus, we assume that an increase/decrease in any of these variables, will have a significant increase/decrease impact on the others.

Fig. 2 illustrate the graphical plot of the series. Looking at the plots, we observed that energy consumption and CO_2 emissions has been declining overtime. Although, decrease in CO_2 emissions seems to be more

Table 1
Data descriptions and sources.

Indicators	Abbreviation unit	Source
Real gross domestic product	RGDP 2010 US$ constant	WDI
Energy usage/consumption	EC Oil equivalent/capita (kg)	WDI
Carbon dioxide emissions	CO_2 Global hectare of land	WDI
Globalization	GLO EC + SO + Political Index	Dreher (2006)[a]

WDI = World Bank Indicators database.
EC = Economic index.
SO = Social index.
[a] The globalization index has been recently improved by Dreher et al. (2008) and Gygli et al. (2018).

Table 2
Summary statistics.
Source: Authors' computation.

	LNCO2	*LNEC*	*LNGLO*	*LNRGDP*
Mean	1.937	7.849	4.279	10.275
Median	1.928	7.855	4.264	10.351
Max.	2.106	8.075	4.407	10.551
Min.	1.662	7.575	4.140	9.778
Std. Dev.	0.110	0.143	0.098	0.234
Skewness	−0.388	−0.023	−0.011	−0.671
Kurtosis	2.577	1.782	1.374	2.177
Jarque-Bera	1.464	2.783	4.955	4.649
Prob.	0.480	0.248	0.083	0.097
Sum	87.177	353.231	192.562	462.408
Sum Sq. Dev.	0.536	0.905	0.427	2.427
Observations	45	45	45	45

Table 3
Pearson correlation results.

Correlation				
t-Statistic				
Probability	*LNCO2*	*LNEC*	*LNGLO*	*LNRGDP*
LNCO2	1.000			
t-Stat	–			
p-Value	–			
LNEC	0.809***	1.000		
t-Stat	9.035	–		
p-Value	0.000	–		
LNGLO	0.510***	0.903***	1.000	
t-Stat	3.888	13.813	–	
p-Value	0.000	0.000	–	
LNRGDP	0.667***	0.939***	0.936***	1.000
t-Stat	5.874	17.996	17.438	–
p-Value	0.000	0.000	0.000	–

Correlation estimates are significant at *** 1% level.

persistent compared to that of energy consumption and real output/income. From a policy perspective, it appears that energy conservation policy introduced to curb environmental pollution by the government is in tune with the country stated macroeconomic objectives. With the increase in the level of globalization (economic, social and political) energy consumption, and real income, carbon emissions level of Italy has been declining rate overtime. This is an improvement in energy conservation-environmental sustainability policies for the nation. In addition, these moves also substantiate the fact that Italy has been successful in fighting environmental pollution and also appears to have achieved the year 2020 target set by the EU for all European countries (European Environment Agency, 2018).[4]

4. Empirical results and discussion

In this section, we present the empirical estimation results and embark on empirical discussion.

4.1. Empirical results

The first method presented in the first and second row of Table 4 below shows the unit root results for Augmented Dickey and Fuller (1979) while the second method presents the Zivot and Andrews (2002) unit root results. The Zivot and Andrew approach to unit root testing controlled for endogenous structural break or regime switching in time series. Findings from Table 4 shows that the variables are not stationary in their level forms, due to the non-rejection of the null hypothesis of a unit root. However, they all become stationary when the variables were differenced at ($p < 0.01$) significance level. Hence, we conclude that the series are all integrated at order one, i.e., $I(1)$. The regime switching (structural breaks) dates as presented in Table 4 for globalization is 1990s and for real income, CO_2 emissions and energy consumption within the 2000s respectively. These dates appears to be of significance to the economy of Italy. Noticeably, it appears the global economic and financial crises experienced between the period 2007–2009 has a rippled effects on the CO_2 emissions, real income/output and energy usage of Italy, as the break dates reported in Table 4 fall in between these periods except for globalization index. The break dates as reported for globalization, substantiate the periods the economy of Italy was integrated into global economy.

Table 5 confirms the long-run relationship among the series via cointegration testing approach that generates the trace and maximum eigenvalue statistics introduced in the work of Johansen (1988, 1991, 1995) and improved upon in the study of Reinsel and Ahn (1992). Findings from Table 5 show evidence in support of at least one cointegration equation for trace at ($p < 0.05$) and Max-Eigen at ($p < 0.10$) significance levels respectively. Hence, we infer that, the variables do follow a stable and long-run equilibrium path.[5]

Table 6 present the short- and long-run coefficients obtained from the ARDL model estimations. Results show that $\ln EC_t$ has a positive and significant impact on $\ln CO_{2t}$ both in the short- and long-run. To be precise, a percent increase in kg oil equivalent per capita of energy consumed will lead to 0.928% increase in metric ton per capita of carbon emissions in the short-run, while a percent increase in kg oil equivalent per capita of energy consumed will lead to 1.796% increase in metric ton per capita of carbon emissions in the long-run at ($p < 0.01$) significance level. Similarly, results also show that $\ln GLO_t$ has a negative and significant impact on $\ln CO_{2t}$ both in the short- and long-run. Results as reported in Table 6 also show that, a percent increase in globalization index (economic, social and political) will lead to 0.914% decrease in metric ton per capita of carbon emissions in the short-run, while a percent increase in increase in globalization index will lead to 1.769% decrease in metric ton per capita of carbon emissions in the long-run at ($p < 0.01$) significance level. However, $\ln RGDP_t$ has no significant impact on the increase/decrease in metric ton per capita of carbon emissions both in the short- and long-run (see Akadiri et al., 2019a, 2019b). Holding all other variables constant, ceteris paribus, the estimated intercept (constant) term was found negative and significant both in the short-run and long-run at ($p < 0.01$) significance level. This indicates that without the impact of energy consumption, globalization and real income/output in influencing CO_2 emissions level of Italy, a percent increase in the constant term will lead to 1.879% decrease in metric ton per capita of carbon emissions in the short-run, and 3.635% decrease in metric ton per capita of carbon emissions in the long-run at ($p < 0.01$) significance level. These results resonate with the findings of Akadiri et al. (2018) and Shahbaz et al. (2018a, 2018b).

In addition, the adjustment coefficient (ECT_{t-1}) as reported in Table 6 shows the short-term speed of adjustment of $\Delta \ln CO_{2t}$ to its long-term steady state path following a shock. As reported in Table 6, the adjustment coefficient is negative (−0.516) and significant at ($p < 0.01$) significance level. From the speed of adjustment estimated coefficient, we infer that deviation from the long-term track of the metric ton per capita of CO_2 emissions is adjusted by 0.516% yearly. This result also provide an evidence in support of a stable long-term relationship among $\ln CO_{2t}$, $\ln EC_t$, $\ln RGDP_t$ and $\ln GLO_t$.

Results as reported in Table 7 show the sensitivity (diagnostic) test. From the results, we found that the specified empirical model is robust, reliable and adequate for policy formulation, since we could not reject

[4] For brevity, we could not compare the entire EU-28 countries. Based on how finding as depicted in Fig. 3 in the Appendix section, United Kingdom has also been able to combat environmental pollution. The graphical plots in Fig. 3 show drastic reduction in kg equivalent per capita of energy consumed and metric tons per capita of carbon emissions over the sample periods.

[5] We use 1 as optimal lag length to estimate the VAR from the unrestricted vector autoregressive model.

Table 4
Stationarity test results.

Method	Form	$LNCO_2$	LNEC	LNRGDP	LNGLO
ADF	Level	−0.804 (0.807)	−1.580 (0.483)	−1.368 (1.000)	−0.546 (0.871)
	Ist Diff.	−5.404*** (0.000)	−6.618*** (0.000)	−4.402*** (0.001)	−4.612 (0.003)
ZA	Level	−0.551	−0.609	−1.148	−2.815
	Break	(2007)	(2007)	(2008)	(2001)
ZA	Ist Diff.	−4.041*** (2007)	−3.327*** (2007)	−3.271*** (2007)	−3.268*** (1993)
	Break				
I. Order		I(I)	I(I)	I(I)	I(I)

Variables are stationarity (stable) *** at 0.01% level.

the null hypothesis that the model is heteroscedasticity, normal distributed and serial correlation free.

On the other hand, the high value $R^2 = 0.950 \rightarrow 1$ of the coefficient of determination of the ARDL-ECM model signify that the adjustment coefficient of the specified model is significantly robust in the short-run. Lastly, the model joint statistic (F-stat = 187.43, p-value = 0.000), which indicate overall robustness and significance of the series is reported significant at ($p < 0.01$) significance level.

Table 8 report Toda and Yamamoto (1995) hence TY, causality testing method. TY is an empirical technique built to test potential predictive relationship that exist between two or more variables. Results as reported in Table 8 row 1 show that globalization index Granger cause CO_2 emissions at ($p < 0.05$) significance level. This finding signifies a one-way predictive relationship from globalization to CO_2 emissions, hence we conclude that, globalization have predictive power over CO_2 emissions. In addition, results (Table 8 row 3) show that energy consumption Granger cause CO_2 emissions and CO_2 emissions Granger cause energy consumption (Table 8 row 4) at ($p < 0.05$) significance level. This finding signifies a two-way predictive relationship between CO_2 emissions and energy consumption. From a policy viewpoint, it appears increase/decrease in energy consumption influences increase/decrease in CO_2 emissions. Furthermore, results (Table 8 row 5) also show that real income Granger cause CO_2 emissions at ($p < 0.05$) significance level. This result also signifies a one-way predictive relationship from real income/output to CO_2 emissions, hence we conclude that real income/output have predictive power over CO_2 emissions. However, we could not reject the null hypothesis of no predictive relationship from CO_2 emissions to globalization (Table 8 row 5) and from CO_2 emissions to real income/output (Table 8 row 6) respectively. This indicates that, CO_2 emissions in this region may not necessarily influence energy consumption and real income output. These results resonate with the findings of Akadiri et al. (2018).

Finally, results show that real income/output Granger cause globalization index at ($p < 0.05$) significance level (Table 8 row 11). This finding signifies a one-way predictive relationship from real income/output to globalization, hence we conclude that, real income/output predict changes in globalization, as globalization could not predict changes in real income/output (Table 8 row 12). Similarly, based on results as reported in Table 8 row 7–10, we could not reject the null hypothesis of no predictive relationship between globalization and energy consumption and between real income/output at all significance level. This signifies the existence of neutrality hypothesis. From a policy viewpoint, changes in globalization and real income/output may not necessarily influence changes in energy consumption and vice versa. These results resonate with the findings of Akadiri et al. (2018) where they found a neutrality hypothesis between globalization and energy consumption in the case of tourist island destination and Shahbaz et al. (2015a, 2015b, 2016, 2017) for India and panel of country.

Table 5
Cointegration results.

No of CE(s)	Eigenvalue	Trace stat.	Prob.	Max-Eigen	Prob.
None*	0.422	48.110**	0.047	23.051*	0.051
At most 1	0.255	25.058	0.159	12.384	0.085
At most 2	0.231	12.674	0.127	11.033	0.014
At most 3	0.038	1.640	0.200	1.640	0.200

We found at least one cointegration equation, significant at ** 0.05 and * 0.10% level.

4.2. Empirical discussion

Empirical results as reported in Table 8 has shown that, energy consumption, real income/output and globalization play a significant role in achieving environmental sustainability in the case of Italy. The impact of these variables in the quest to curb or reduce to minimal greenhouse gas emissions and enforce environmental sustainability both in the short-run and long-run can never be overemphasized. Interestingly, we found that increase in kg oil equivalent per capita of energy consumed country appears to have decreasing impact on CO_2 emissions level. This result has been argued in energy-literature. It is expected that the higher the kg oil equivalent per capita of energy consumed, the higher would be the metric ton per capita of carbon emissions (see Bekun et al., 2019b; Alola, 2019a). However, in the case of Italy, the reserve seems to be case, despite the two-ways predictive relationships recorded among energy usage and CO_2 emissions. In Fig. 2, it was observed that, increase in the kg oil equivalent per capita of energy consumed leads to more reduction in metric ton per capita of CO_2 emissions. This result is confirmed in Table 7. From the policy perspective, we suggests Italy has been successful in fighting environmental pollution and sustaining cleaner environment, due to energy conservation policy embarked upon as it well-balanced with the EU climate and energy 2020 targets.

In addition, result show that increase in the level of globalization through trade openness has an inverse impact on environmental pollution in Italy. This indicates that the government and policymakers of Italy have put in place sound energy and macroeconomic policies. We

Table 6
ARDL-ECM estimation results.

	Coeff.	p-Value
Long-run coeff.		
Regressors		
lnEC	1.796***	(0.000)
lnRGDP	−0.093	(0.467)
lnGLO	−1.769***	(0.000)
Const.	−3.635***	(0.000)
Adjustment coeff. (ECT_{t-1})	−0.516***	(0.000)
Short-run coeff.		
Regressors		
lnEC	0.928***	(0.000)
lnRGDP	−0.048	(0.448)
lnGLO	0.914***	(0.000)
Const.	−1.879***	(0.000)
R^2	0.950	
Adj. R^2	0.945	
F-stat	187.430***	0.000

Regressors are stationarity *** at 0.01% level.

Table 7
Sensitivity check.

Diagnostic test	Coeff.	p-Value
Heterogeneity	0.227	0.214
Normality	1.193	0.550
BG autocorrelation	3.121	0.096

Note: BG represent Breusch-Pagan autocorrelation test.

infer that environmental policies and macroeconomic objectives of Italy are in tune with their energy-conversation policy. It will be theoretically right to assume that as an economy become more open to the rest of the world in terms of trade via importation and exportation of energy products, production would increase, hence a rise in the pollution level. However, it appears government and policymakers of Italy have been able to overturn the tide. We observed that, the more the economy of Italy become open through trade, the less their emissions level, hence increase in environmental quality. This finding is confirmed by the neutrality hypothesis reported between globalization index and metric ton per capita of CO_2 emissions reported in Table 8, row 7–8. Globalization level in Italy be it economic, social or political has no predictive power over the metric ton per capital of CO_2 emissions generated in the sampled country. Thus, increase/decrease in globalization index may not necessarily influence increase/decrease in environmental pollution (see Akadiri et al., 2018; Shahbaz et al., 2018a, 2018b; Alola, 2019a; Bekun et al., 2019a, 2019b).

Furthermore, it has been argued that the higher the level of economic (production) activities, the higher the metric ton per capita of CO_2 emissions generated, and vice versa (Bekun et al., 2019b; Alola, 2019b; Akadiri et al., 2019a, 2019b). However, our empirical result show that real income/output has no significant impact on CO_2 emissions in Italy both in the short- and the long-run. This result indicate that, environmental pollution in Italy is not output driven. It appears production activities in the sampled country has moved from non-renewable energy sources to renewable due to introduction of energy saving technologies (see Akadiri et al., forthcoming). From the policy perspective, it appears Italy in an energy-independent economy. Thus, economic growth is not a function of energy consumed and/or produced. By implication, increase in real income would not contribute to increase in metric ton per capita CO_2 emissions, while the introduction of energy conversation policy to maintain and sustain sound and cleaner environment would not by any chance slow down economic performance or hurt the economic growth process of Italy. This finding is confirmed by the neutrality hypothesis reported between real income/output and metric ton per capita of CO_2 emissions reported in Table 8, row 9–10.

Finally, our empirical discussion will be incomplete without pointing out the significance of the estimated coefficients reported for the constant terms both in the short-run and long-run (Table 6). If there is one particular policy implication one can suggest from the negative and statistically significant coefficients of this autonomous term on the metric ton per capita of carbon emissions is that, the economy of Italy is immune to environmental pollution, as the government and policymakers have put in place alternative measure of energy saving technologies to combat CO_2 emissions level and sustain the environment for both the immediate and future generation. The energy and environmental policies set by the EU to fight climate change and replace non-renewable energy for renewable ones that emit less carbons, tagged targets 2020 which has been recently upgraded to 2030 are in tune with the stated macroeconomic objectives of this region. The invisible forces of energy demand and supply seems to have been curtailed in such a way that, even without energy conservation policy in place, which is through decrease in energy consumption as the economy grows and become more globalized through trade and foreign investment, the metric ton per capita of carbon emissions will continue decreasing, thus improvement in environmental quality. Based on these findings, it will be theoretically right to conclude that, Italy has achieved a lot in term of sustaining their environment both for the present and generation to come.

Table 8
Granger causality (GC) results.

Regressors	MWald	p-Value	Causality
$lnGLO \rightarrow lnCO_2$ (1)	6.356**	0.041	*Yes*
$LnCO_2 \rightarrow lnGLO$ (2)	1.170	0.557	*No*
$lnEC \rightarrow lnCO_2$ (3)	8.818**	0.012	*Yes*
$LnCO_2 \rightarrow lnEC$ (4)	7.968**	0.018	*Yes*
$lnRGDP \rightarrow lnCO_2$ (5)	7.020**	0.029	*Yes*
$LnCO_2 \rightarrow lnRGDP$ (6)	3.488	0.174	*No*
$lnGLO \rightarrow lnEC$ (7)	1.221	0.542	*No*
$LnEC \rightarrow lnGLO$ (8)	1.384	0.500	*No*
$lnEC \rightarrow lnRGDP$ (9)	4.030	0.133	*No*
$LnRGDP \rightarrow lnEC$ (10)	0.204	0.902	*No*
$lnRGDP \rightarrow lnGLO$ (11)	6.392**	0.040	*Yes*
$LnGLO \rightarrow lnRGDP$ (12)	3.121	0.209	*No*

Regressors are stationarity *** 0.01 and ** 0.05% level.

5. Conclusion and policy suggestions

In this paper, we examine how far the economy of Italy has gone in achieving cleaner and environmental sustainability targets put forward by the European Environment Agency. The purpose of these targets is towards environmental sustainability of the European Union countries. In order to achieve our research objective, we examine the role, interaction and interconnectedness of globalization, energy consumption and real income/output on carbon emissions proxied for environmental pollution over the period 1970–2014 for Italy. This is done to examine whether the integration of Italy into the global economy, where energy resources are mostly traded in order to enhance economic growth and development, the region has achieved their environmental sustainability targets or not, using the autoregressive distributed lag approach for empirical estimators and Toda and Yamamoto (1995) for predictive relationship analysis.

From our graphical and empirical results, we found that Italy is not an energy-dependent economy, thus, the region is immune to environmental pollution, which indicate a pathway towards achieving environmental sustainability targets. This result is confirmed by the inverse relationship we obtained between globalization and real income on carbon emissions level. In addition, we found that increase in globalization and real income have decreasing impact on environmental pollution. Even with the increase in kg oil equivalent per capita of energy consumed, CO_2 emissions level of Italy has been declining overtime, hence improvement in environmental quality. By implication, Italy energy and environmental policies are in line with their macroeconomic objectives. Thus, the economy appears to have achieved their environmental sustainability targets, a move towards cleaner environment for both the immediate and future generation.

Conclusively, the findings of this study are indicative for both the government, policymakers and scholars in the field of energy, due to the fact that, Italy is one of the most dynamic economy in the world, where production activities are associated with different energy resources, and highly globalized economy. Findings of this study propose crucial policy suggestions for governments and policymakers that is working towards reducing carbon emissions level and promote sound and cleaner environmental policies. Our study has proved that, real income, globalization and kg oil equivalent per capita of energy usage had a decreasing impact on metric ton per capita CO_2 emissions level. This result shows that energy/environmental conservation policies are in tune with macroeconomic objectives in the case of Italy (Akadiri et al., 2019b). Thus, findings of this present study propose that, while kg oil equivalent per capita of energy consumed and globalization enhance economic growth in Italy, energy/environmental protection policies are in accordance with economic growth policies and objectives.

This raises a clue for nations battling with environmental pollutions to emulate, "integrate energy and environmental policies with macroeconomic goals, in order to achieve economic and environmental sustainability". The position of Italy in terms of environmental quality and sustainability is a lesson to world economies in general that is still lagging behind in their effort to combat environmental pollution. The findings this study is similar to the findings of Katircioğlu (2014) for Singapore where they argued that environmental conservation policies are well-balanced with macroeconomic targets and Lee and Brahmasrene (2013) for the EU countries.

Appendix A

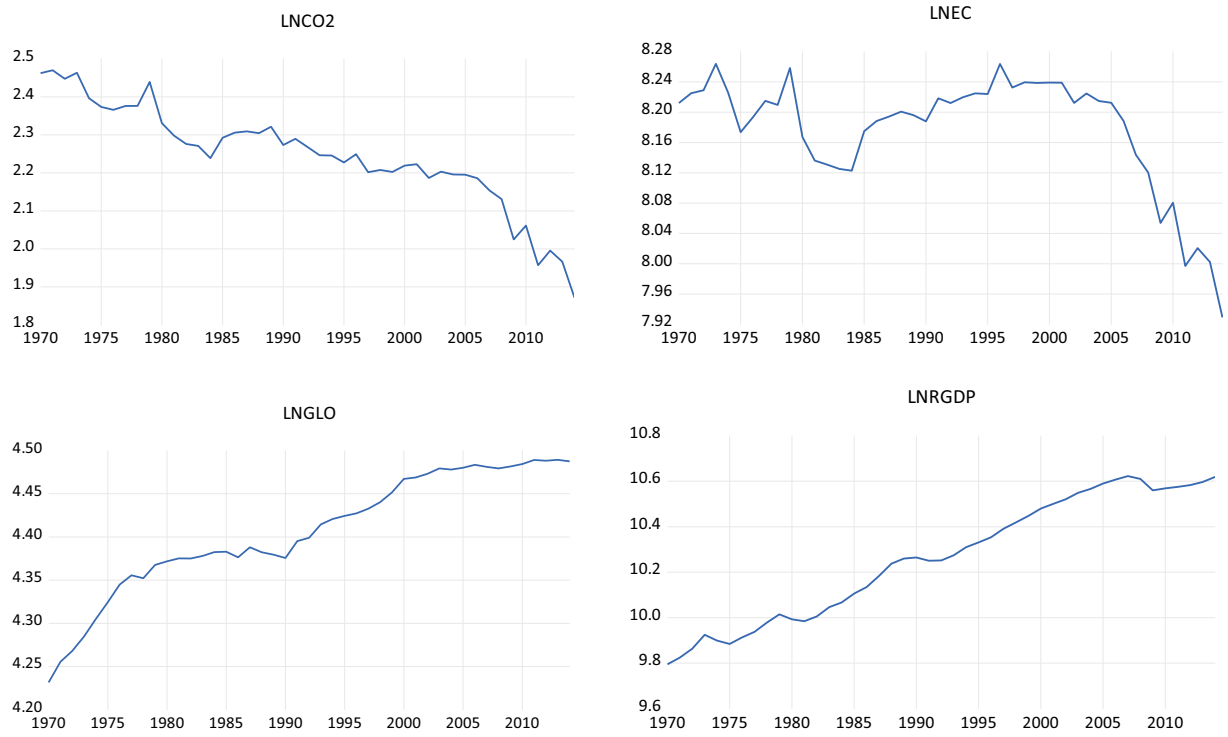

Fig. 3. Graphical plots of the natural logarithms of $lnCO_2$, lnEC, lnRGDP and lnGLO for United Kingdom.

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